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A NEWS LETTER FOR EXTENSION WORKERS INTERESTED IN PLANT DISEASE CONTROL

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FORAGE CROP DISEASES

At the Philadelphia meeting of the American Phytopathological Society, December 28, 1940, the Committee on Extension Work and Relations of that society sponsored a conference on Recent Studies of Forage Crop Diseases. Attention was focused on diseases of alfalfa, winter legumes, and grasses. The present situation with regard to these diseases was outlined; some problems needing further experimental work were indicated; and discussion was invited. Dr. Luther Shaw of North Carolina was conference chairman. A summary of the conference follows, with remarks of discussion leaders.

ALFALFA DISEASES

By Lawrence Henson,
Assistant Agronomist
Kentucky Agricultural Experiment Station

Alfalfa, in many respects, is an ideal plant for study by the plant pathologist. This is particularly true if he is dominated by a desire for complex and often perplexing problems.

More than 85 genera of fungi representing well over 150 different species have been reported from one place or another as pathogenic to alfalfa.* Bacteria are the causal agents of three or more distinct diseases. Eight or more viruses are capable of attacking alfalfa. Nutrient starvation (boron and potassium) may produce abnormalities which the plant pathologist will often be called on to diagnose. Numerous insects (potato leaf hopper, aphids) infest the plants of alfalfa. This panoramic association of fungi, bacteria, viruses, nutrients, and insects, independently, collectively, and in various combinations with the physical environment (heat, cold, and drought)

*For a summary of the fungi reported on alfalfa, I am indebted to Dr. S. J. P. Chilton of Louisiana State University.

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produces a complex problem in an evaluation of alfalfa diseases. The problem is complicated still further by the fact that alfalfa is a pe perennial plant.

Since its discovery in 1924, bacterial wilt, due to Phytomonas insidiosa, has constituted the most serious threat to alfalfa growing in the United States. This threat to the growth of alfalfa has been investigated more thoroughly than any other diseases of the crop. Progress has been made in these studies. It is now known that the disease cannot be controlled by cultural practices, only influenced by them. Ladak and Cossack are somewhat less susceptible to wilt than Grimm and, where the disease occurs, usually maintain satisfactory stands 1 or 2 years longer. Hardistan and Orestan, two new varieties, are more resistant, but the supply of seed is as yet limited. The most promising control measures, as with most forage diseases, is the development of desirable resistant varieties. By the use of artificial inoculations, highly resistant lines of alfalfa have been obtained. From these lines new varieties are being developed. However, seed of these varieties are not yet commercially available.

Future problems in alfalfa-wilt investigations appear to be: (1) A thorough study of the variability of the bacteria; (2) refinement of the inoculation technique; and (3) development of more highly resistant lines.

Black-stem caused primarily by Phoma medicaginis (Ascochyta imperfecta) is another important disease of alfalfa which is widely distributed. It produces leaf spots and stem blackening which result in partial defoliation and in death of the young shoots. The disease is favored by mild winters followed by long, cool, wet spring seasons. It is reported as most severe in the South and West. In Kentucky, Johnson and Valleau observed differences in the degree of injury caused by Phoma medicaginis to varieties of alfalfa, but little is known concerning the susceptibility of the commonly grown commercial varieties. Encouraging results in the control of this disease have been obtained by spring grazing. Although results are encouraging, nothing is known as to the effect of this treatment on the longevity and yield of this crop. The possibility of control by cultural practices is a problem which deserves further study.

Stem-rot produced by Sclerotinia trifoliorum may reduce the stands of fall-sown alfalfa the first spring in Kentucky. The disease is widespread, but most severe in Oregon and the Southeastern States. The fungus is most active in late winter and early spring when it rots the stem bases and taproots, causing death of the plants.

"Damping-off," the causal agencies of which are generally the pythiaceous fungi is a problem the importance of which is not known. The distrubution and importance of the anthracnose-producing fungi is something else concerning which there is a dearth of information.

Downy mildew, rust, and the leaf spots caused by Pseudopeziza medicaginis, Pyrenopeziza medicaginis, Pseudoplea briosiana, Macrosporium sarcinaeforme and Cercospora zebrina are some of the more common foliage diseases concerning which our information is limited. As a result of the alfalfa-breeding program, the importance of any one of these diseases may change as new varieties are released and established. If varieties are produced which are more nearly homozygous for disease reaction than those now commonly grown, an opportunity for increased destructiveness will exist. A careful watch for this possibility should be maintained.

Opportunities for future work.

The uniform alfalfa nurseries which are established in 35 States may very profitably be watched for diseases. They offer an excellent opportunity for a measurement of the reaction of these varieties to the diseases prevalent in their localities.

The need for accurate determination of the causal agents of the leaf-spot diseases may be emphasized by results from these nurseries in 1938 and 1939. Not a single variety in the top 10 strains in 1938 is included in the top 10 in 1939, although some strains ranked high both years (Ladak).

Some problems which apply in a greater or less degree to nearly all diseases of alfalfa are:

1. Methods for measuring the importance of the diseases. Applies to diseases that do not produce a lethal effect.

2. Cultural practices as they influence development of diseases, as well as longevity and continued yield of the crop.

3. Obtaining accurate records of diseases present.

4. Variability of organisms producing the diseases.

5. A thorough knowledge of the life history of the organisms.

6. Rapid practical methods of artificial testing for resistance and susceptibility.

The extent to which these problems are solved will measure in some degree the contribution of pathologists to the development of successful varieties of alfalfa possessing desirable agronomic characteristics and highly resistant to disease.

In the discussion of this subject, B. L. Richards (Utah) pointed out the difficulty in distinguishing between black-stem and Sackett's bacterial stem-blight of alfalfa. He has an idea that there is a difference, but as yet has not been able to prove it or to repeat Sackett's work.

In reply to a question asking if there are any downy-mildew-resistant alfalfas, Henson said that none is available, but that in experimental work, both in this country and Sweden, definite differences in susceptibility and resistance have been noted.

Howard W. Johnson (U. S. D. A.) called attention to the variability of both alfalfa and the pathogens and the need for working with known materials.

Clonal lines of alfalfa and single-celled cultures of the organisms are desirable although single-celled cultures of Phytomonas insidiosa are difficult to obtain.

Johnson said pathologists had an opportunity to uncover some valuable information on diseases occurring among the many lines of alfalfa growing in the uniform alfalfa nurseries. To aid in taking notes in these nurseries, F. R. Jones and Johnson have prepared suggestions and a key telling what may be expected from the different cuttings. (See Appendix, page 24.)

J. G. Brown (Arizona) inquired if anyone had difficulty in isolating the bacterial-wilt organism. J. B. Kendrick (Calif.) said that they do not have difficulty, and suggested that possibly in Arizona they were dealing with alfalfa dwarf.

J. L. Weimer (U. S. D. A. -Ga.) pointed out that the top symptoms of these two diseases are alike, and further stated that the wilt organism is slow to appear in culture. Johnson said it has generally been considered that the wilt organism was the only pathogenic gram-positive bacterium to be isolated from discolored alfalfa roots. However, in view of recent findings by F. R. Jones and O. F. Smith this may not hold true.

O. S. Aamodt (U. S. D. A.) said that the wilt-resistant composite of alfalfa A136 should be mentioned and should be observed when growing in the uniform nurseries. In the case of A136, breeders have selected eight strains tracing to five different sources and have composited them. The strains making up A136 have been tested in the uniform nurseries four years. The composite is now being increased for testing in advanced nurseries. About 900 pounds of seed were produced in 1940. Pathologists should watch A136 and make observations on disease incidence as they will doubtless receive inquiries regarding its behavior.

Kendrick asked for information on Fusarium wilt of alfalfa from other States. In California, Fusarium wilt is becoming more prominent.

DISEASES OF AUSTRIAN WINTER PEAS AND VETCHES

By J. L. Weimer
Senior Pathologist, Division of Forage Crops and Diseases
United States Bureau of Plant Industry

The diseases of the English pea have been studied for many years, not only in this but in foreign countries. Since the Austrian winter pea and the English pea, are susceptible to most of the same diseases, the information obtained from the study of diseases of the garden and canning varieties of English pea applies equally well to the Austrian winter pea. So far as I know, only a few pathologists have worked on the Austrian winter pea diseases affecting cover-crop production in the South. Dr. J. L. Seal of Alabama has devoted considerable time to this problem, and the agronomists of several of the Southern States have been searching for disease-resistant parent types and doing some breeding work in an effort to improve the Austrian winter pea. They have also been testing a number of varieties of vetches, some of which are attracting much attention. Several workers have contributed to our knowledge of vetch diseases.

I have confined my efforts largely to the control of diseases most troublesome in the South. I shall, therefore, review briefly those diseases and discuss the type of injury they produce under southern conditions.

The seriousness of these diseases varies from year to year, from one locality to another, and even from field to field. However, black-stem, caused by Mycosphaerella pinodes and Ascochyta pinodella, seems to rank first in most places. The symptoms caused by these two fungi are so nearly alike that I am not able to distinguish between them without microscopic study. Both produce a blackening of the stem, a leaf-spot, and sometimes a darkening of the pods. Blackening of the stem is commonly the most conspicuous symptom, therefore the name "black-stem" seems appropriate. On land that has grown crops of peas 2 or more years in succession, the extent of the injury caused by this disease is sometimes considerable.

Perhaps the next most destructive disease is leaf-blotch, caused by Septoria pisi. This disease usually is the first to appear in the fall. The fungus kills the young leaflets and often runs down the petiole into the stem, which may be girdled and the portion of the plant above the girdle killed. Later in the spring, leaves and tendrils are killed and pods are sometimes attacked. The fungus may grow through the pod into the seed.

Root-rot (Aphanomyces euteiches and Pythium sp.) is sometimes the most destructive disease, especially on wet soil or during a very wet spring. The affected plants are dwarfed, yellowish in color, and gradually die. All plants in large areas of a field may be severely injured or killed.

Powdery mildew (Erysiphe polygoni) becomes quite abundant on pea plants in South Georgia before they are plowed under, but seldom appears so early in Central Georgia. This disease is not of much importance unless seed production is attempted.

Some less important diseases are bacterial blight (Phytomonas pisi). downy mildew (Peronospora pisi), mosaic, Fusarium root-rot (F. martii var. pisi), and Sclerotinia (S. sclerotiorum) stem-rot.

The most destructive diseases of vetches that have come to my attention are root-rot and Protocoronospora (nigricans) leaf-, stem-, and pod-spot. Root-rot is most serious on common vetch; the Protocoronospora, on hairy vetch. Ascochytas may be quite destructive on some varieties of vetch in some localities but, in general, these fungi have not been found to be very serious on vetch in Georgia.

This covers the most important diseases of peas and vetches which have come to my attention. Wilt (Fusarium oxysporum f pisi race 1), near-wilt (F. oxysporum f pisi race 2), Ascochyta pisi, the viruses, and other diseases which attack English garden or canning peas in other sections of the country have given us no trouble.

Disease resistance.

The diseases with which we are concerned are largely soil borne, and as we have no practical method of sterilizing soil on a field scale, considerable time has been spent in a search for resistant parents, and this in turn has led to a breeding program. I wish to point out what have seemed to be some chief objectives of a breeding program.

Objectives

1. Pest control -
   a. Disease resistance.
      Black-stem and leaf-spot, leaf-blotch, root-rot, powdery mildew, bacterial blight.

   b. Insect resistance.
      Pea aphid, pea weevil.

2. Make seed production in the South practical.
3. Increase winter hardiness.
4. Increase vegetative vigor.

From the pathologists' viewpoint, disease resistance, of course, is the chief objective, but certain other limiting factors must be kept in mind.

In an effort to find a winter pea that is resistant to these diseases, several hundred varieties or seed lots have been tested, both in the field and in pots held in hotbeds and inoculated artificially. There is some variation in susceptibility, but no highly resistant

plants have been observed. Crosses have been made using the Austrian winter pea and the least susceptible plants found, but thus far nothing very encouraging has appeared. Because the Austrian winter pea is the most hardy of all lines tested, it has been used as one parent in all crosses.

Rotation.

Until more highly resistant strains of peas are found, our most hopeful method of controlling diseases of peas is by rotation. Fortunately this holds some promise. Observations on experimental plots and commercial fields have shown that when peas are grown on the same land not more than 1 year in 3, the plants are much freer of pathogens, especially the Ascochytas and Septoria. For several consecutive years, peas have been almost a failure in some plots on the Georgia Experiment Station farm, where they have been grown every year, but adjacent plots or plots nearby, that were planted to peas 1 year in 3 have produced a good yield. A still longer rotation would give better disease control, but a short rotation is desirable because the soil needs a cover every year to prevent erosion, and in some localities few substitute crops acceptable to the farmer are available. It has been my observation that if a grower plants peas on the same piece of land, only 1 year in 3, if he avoids poorly drained land, and if he uses the necessary amount of fertilizer to insure good growth, he will obtain reasonably good commercial control of the diseases of both peas and vetches.

Summary.

To summarize briefly, there are several diseases of Austrian winter peas, but black-stem, leaf-blotch, and the root-rot are the most destructive. Root-rot and Protocoronospora on the leaf, stem, and pod are the most destructive diseases of vetches.

Future work.

In closing I should like to suggest necessary improvements in the Austrian winter pea, and to encourage its further use.

1. Disease-resistant parent peas to use in a breeding program.
2. Strains of peas resistant to aphids and the weevil.
3. A pea that will set seed well, so the farmer can grow his own seed.
4. More substitute crops, preferably legumes resistant to pea diseases, which can be used in the rotation. Some legumes are now available, such as crimson clover and bur clover, but they are suited only to certain sections.
5. Greater winter hardiness, so the geographical range of pea growing can be extended.
6. Further evidence from localities regarding the efficiency of a 3-year rotation in controlling pea diseases.

There is a place for a winter-hardy, disease-resistant, high-yielding, and good seed-setting vetch. The hairy vetch is fairly satisfactory, but has objections in that it does not set a very satisfactory seed crop, volunteers too freely, and harbors certain insects. Willamette vetch, a strain of common vetch, selected by Roland McKee of the U. S. Department of Agriculture several years ago and grown in Oregon since, is being tested in several places, especially in northern Alabama, and seems to meet the above specifications. It still needs further study, however. A thoroughly satisfactory vetch would probably replace Austrian winter peas in many localities unless the peas can be improved.

In discussing this topic, the relation of winter hardiness to disease was commented on. H. B. Humphrey (U. S. D. A.) said that some plants are less winter hardy if diseased, as, cereals with rusts and smuts. St. J. P. Chilton (La.) said there is no correlation between rust on white clover and winter hardiness but in timothy there is. W. D. Valleau (Ky.) suggested that a possible explanation is that the cereals are homozygous, but white clover is not. Weimer mentioned that frozen tissues of peas are more susceptible to Ascochyta infection than uninjured tissue.

The question of the root-knot susceptibility of winter peas and their role in a rotation for root-knot control came up. Weimer said that the root-knot nematode was giving some trouble to peas on sandy soils. The effect of peas and other leguminous crops on root-knot infestations of following crops needs study. Luther Shaw (N.C.) seemed to think that there may be a definite danger in the use of peas through the building up or maintaining of nematode populations. They should fit into a rotation designed with reference to root-knot.

DISEASES OF TURF AND FORAGE GRASSES

By John Monteith, Jr.

Director of the Greens Section, United States

Golf Association, Washington, D. C.

(Dr. Monteith's talk was accompanied by a showing of kodachrome slides illustrating symptoms and results of control measures.)

Until comparatively recent years, the fungi causing diseases of grasses, other than cereals, have received little attention except for the mycological collections. The large number of species of grasses

and the great variety of locations where they grow provide conditions favorable for the growth of a large number of fungi which may cause serious diseases. Without a doubt, grasslands are damaged considerably each season by diseases. Even in mixed stands, grass diseases may injure the stand so seriously that there is not only a direct loss to the grass plants, but a loss by the invasion and establishment of weedy plants as a result of the removal of the competition offered by vigorously growing grass. Once the weeds are established, the grass plants may be unable to take over the area again.

On the other hand, in some instances, in mixed populations such as exist in pastures, the actual loss from diseases may be much less than would be the case in pure stands. This is due to the fact that when grasses are injured by diseases, other plants such as clover may crowd in and replace them. Such changes may be beneficial.

Diseases of grasses have been studied more carefully in turf than in other grassland. This has been due largely to the more intensive cultivation of turf and the greater willingness of growers to make more liberal expenditures on control measures. Diseases of turf that are most common and that have been studied most are brown-patch, caused by Rhizoctonia solani; and dollar-spot, caused by Sclerotinia homoeocarpa. Another common summer disease is spot-blight, caused by Pythium butleri. Other species of Pythium have also been found associated with damping-off of grass plants. These diseases develop during the growing season. Snow-mold, which affects grass in much the same manner, develops in cold weather when the plants are dormant or just beginning to grow. It may be caused by several different fungi, but the chief one in this country appears to be Fusarium nivali.

All the above diseases develop in patches and may entirely destroy the affected turf, or may thin out the stand so badly that weeds may gain a foothold before the grass can recover. All of them have been observed on a great variety of turf grasses and are widely distributed throughout the country. They result in much disfigurement of turf and often necessitate resodding or reseeding. None of them, however, has as yet been regarded as the cause of serious losses of forage crop grasses, It is possible, however, that as grasses are more widely studied these diseases will be found to be important in grasslands in general.

Among common leaf-spot diseases of grasses, the one on Kentucky bluegrass, caused by Helminthosporium vagans, has perhaps received most attention. It is prevalent in lawns and recreation fields and has been found to be abundant in pastures. Under favorable conditions this disease may be so abundant that stands of bluegrass are so discolored as to appear to be suffering from severe drought. The crown-rot stage kills large areas of Kentucky bluegrass, especially when kept cut short. Very likely the disease also weakens plants and makes them more susceptible to other injuries. Probably the grasslands in general suffer more from attacks of various species of Helminthosporium than is assumed. Other similar types of leaf diseases occur and, under certain conditions, may cause severe damage.

Rusts and smuts and also ergot cause an undetermined but very appreciable amount of damage in forage grasses. There is less trouble in closely cut grass, from these diseases, than in hay or seed crops where the plants are allowed to grow to maturity.

Control measures for forage grasses are naturally restricted. The usual methods involving rotation or spraying are generally impractical. In the case of turf grasses, however, spraying is entirely practical, particularly in the case of the more intensely cultivated grass areas, such as putting greens and highly developed lawn areas.

The development of disease-resistant grasses offers the more promising solution. Selected resistant strains of bentgrass have been used for many years to reduce the damage to turf resulting from brown-patch, dollar-spot and snow-mold. In more recent years, selections of bluegrasses have been made which show decided resistance to Helminthosporium vagans. Cases of definite resistance to other troublesome grass diseases have been observed, and undoubtedly the development of such resistant strains will ultimately serve to reduce the damage from the most troublesome diseases.

An immediate problem in the study of grass diseases seems to be that of determining what diseases are most destructive in grasslands. Much of the loss of grass probably is due to diseases that have not as yet been recognized. Even in turf fields, where more study has been made than on other grasslands, the actual amount of experimental work is very little compared with the studies which have been made on the diseases of most of our crop plants. With forage grasses, the lack of information on diseases is even more obvious. With the increased interest in grassland culture, it can be logically expected that the diseases of these plants will become increasingly interesting and important.

C. L. Lefebure(U. S. D. A.) brought out the fact that Dallis grass (Paspalum dilatatum) is very susceptible to ergot, but that Paspalum malacophyllum is apparently immune, and that some hybrids have resistance.

Howard Johnson discussed leaf-spot of grasses caused by Helminthosporium vagans. Whole pastures of Kentucky bluegrass that were brown because of this disease have been seen in Pennsylvania, and he urged pathologists in other States to make observations on the prevalence of this disease.

Henson pointed out that grasses now are heterozygous, which may account for the unimportance of some diseases. However, as clonal or selfed lines are grown in observation nurseries, we may get a better measure of the importance of various diseases.

Chilton raised the following question: In improving these grasses should one eliminate plants on the basis of diseases that may become importatnt? In his studies he had 1,200 timothy plants, all but 2 of which became rusted when inoculated and yet, when he goes out into the field, it is difficult to find any rust on timothy. If all susceptible plants were discarded, wouldn't he be throwing away many valuable genetic factors?

O. S. Aamodt's remarks made a fitting close for the forage crops disease session. He pointed out that, until recently, forage crops in the United States have not received much attention along lines of improvement. However, from 1936 to date a definite start in that direction has been made. The improvement program with forage crops will have to go through a development similar to that of cereals, cotton, and other crops. It is essential that pathologists make their contributions to disease problems of this group of plants as they have in the case of these other crops.

At present there are 200 or more Soil Conservation Service, Bureau of Plant Industry, and Experiment Station nurseries over the country. These offer an opportunity for pathologists to study disease reactions and to obtain valuable information. Advantage should be taken of this opportunity. The pathologist should assist the agronomist in making evaluations of grasses. Agronomists need help in distinguishing between the different diseases and in arriving at a definite determination of their identity. One-half of the United States is covered with grass. Some 200 agronomists are trying to evaluate grass. It is important that diseases be duly recognized and detailed and accurate data recorded concerning them.

SUGGESTIONS FOR THOSE TAKING NOTES ON DISEASES IN ALFALFA NURSERIES

GENERAL

Prepared by F. R. Jones and H. W. Johnson, Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

It should be noted in connection with taking notes on diseases in the alfalfa nurseries that although the recording of the presence of a certain disease in that nursery is of interest, the main object of the recording is to discover differences in ability of the selections under test to escape or resist disease. Thus the emphasis is upon differences in disease, and upon real and significant differences, not upon the mere existence of disease. It must not be overlooked that differences that are real may not be significant for the purpose in mind. For instance, a rainy period immediately following the cutting of the nursery may have as a consequence a heavy infection with the Pseudoplea leaf-spot on those selections which recover more promptly, whereas those recovering later after the rain may escape.

Difference in infection in such a case is real, but not necessarily significant, as a later period of rain with reference to cutting might have reversed the order of infection among the selections. Differences in density of stand may affect greatly the apparent injury from leaf-spot where no innate difference in resistance to leaf-spot exists.

Thus the value of records depends not only upon an accurate comparison of conditions of disease at the time at which the records are taken but often even more upon a knowledge of the entire history of the development of the disease. From this the recorder can decide whether the observed difference is due to some character inherent in the plants or to some accidental circumstance in the relation of the plants to the environment.

Moreover, it is readily seen that from the point of view, of both the man who takes the records and the man who compiles the records, it is desirable that each disease be dealt with separately. Unfortunately, it often happens that several diseases are present together, and must be recorded together, if at all, with such explanation of the circumstance as may seem useful. The inter-relationship of diseases in conbinations is likely to make the interpretation of those records difficult if not impossible, and it hardly need be said that the making of records which are not capable of useful interpretation is a waste of time, not only for the one who takes the record, but for him who tries to relate this record to others. It must often happen, therefore, that records must be taken of each disease as it appears during the season, and sometimes more than once, if the same disease develops in successive cuttings.

Since the nurseries are widely scattered in the United States, the list of diseases which may appear in them is long. Some of these lack common names; with some a common name has been extended to cover several diseases so that for our present purpose it is useless without redefinition. Some of these diseases do not have easily distinguished characters which may serve to identify them at all stages in development; and thus descriptions supplemented by illustrations can hardly be prepared in a manner adequate to meet the need of the recorder who does not know the diseases already.

In an attempt to aid the recorder in identifying diseases the following key has been prepared and it is hoped that it will not be as likely to mislead as lengthy descriptions. In case of doubt, perhaps in all cases, a record should be supported by a liberal herbarium specimen which can be submitted to a mycologist or plant pathologist for identification.

Key to Diseases

I. Systemic infections.

A. Bacterial wilt caused by Phytomonas insidiosa.

Widely distributed but may not appear in some nurseries in the Northeastern and Southern States.

Dwarfed plants with small, abnormal shaped leaves of a yellow or pale green color are the first evidence of the disease above ground. Infected plants gradually weaken and die. Confirming evidence of wilt infection is the yellow color in the wood of the roots just under the bark. Wilting of top growth may appear during summer droughts.

B. Mosaic and other virus diseases.

1. Alfalfa mosaic is of widespread occurrence and becomes evident during the cool weather of spring and fall. Affected plants are stunted and are characterized by a definite yellow and green mottling of the leaves.

2. Alfalfa dwarf occurs so far as known only in southern California where its symptoms and effect on the alfalfa stand are almost identical with those of bacterial wilt. It can be distinguished from wilt, however, by the fact that the leaves of the dwarfed plants are normal in color or of a slightly darker green than healthy plants and are small but practically normal in shape.

3. Witches' broom or bunchy top of alfalfa has been reported from Utah and Washington. In the latter State it is said to be prevalent and destructive in certain irrigated valleys. Witches' broom plants are light green in color, short and dense, being composed of from 200 to 800 short shoots. Leaves are dwarfed, rounded to heart-shape and are frequently cupped.

II. Stem diseases.

A. Diseases chiefly of early spring or of the first crop.

1. Black-stem caused by Ascochyta imperfecta.
Omnipresent, but most severe in south and west. Develops in cool, wet weather. Blackening extends from base upward. Slender stems become brittle and may break. Causal fungus rarely fruits on stems until they are dead, thus making identification by observation difficult.

2. Bacterial stem-blight caused by Phytomonas medicaginis. (Often confused with the above and called black-stem.) Mountain States diminishing eastward to Missouri River. Often follows frost and wind with rain. In early stages, green, watersoaked, often becoming yellow, brown, but finally blackening. In stripes and not encircling the stem as frequently as true black-stem. Clear bacterial exudate seen in early stage giving stems a shiny varnished appearance. When blackened, easily confused with true black-stem.

3. Stem-rot caused by Sclerotinia trifoliorum. Common in western Oregon and in the Southeastern States. The fungus is most active in late winter and early spring when it rots the stem bases and upper taproots, causing the death of the attacked plants. Black fungous sclerotia at the plant's crown are a sign of the disease.

B. Diseases chiefly of summer, or of second and subsequent crops.

1. Anthracnoses, three in number, caused by three species of Colletotrichum commonest of which is C. trifolii. Chiefly Southern and Middle Atlantic States. Dark lesions on stems and petioles resulting in wilting of leaves above infected parts. Black fruiting dots of the causal fungus often occur on the stem lesions. These diseases cannot be readily differentiated and should be referred to a mycologist or plant pathologist for identification.

III. Foliage diseases.

A. Diseases chiefly of early spring and of the first crop.

1. Downy mildew caused by Peronospora trifoliorum Widely distributed, but more severe in the Mountain States. Infected shoots dwarfed, leaves curled, gray downy growth on under surfaces of leaves; or yellow spots more or less abundant on leaves with or without the downy fruiting beneath. Well known.

2. Ascochyta leaf-spot caused by Ascochyta imperfecta. The black-stem fungus may cause a serious leaf-spot epidemic soon after growth commences in the spring if the weather is cool and moist. The leaf lesions are of variable size, irregular in shape, on the edge or in the middle of the leaflets and dark brown or black in color. Leaves bearing many lesions yellow and wither, and the young shoots may die as a result of defoliation and stem infections combined. This stage of the disease is much more injurious than the more obvious blackening of the stems which is evident later in the spring.

B. Diseases chiefly of summer or of second and subsequent crops.

1. Leaf-spot caused by Pseudopeziza medicaginis. Omnipresent, but suppressed in absence of rains or heavy dews. A circular delimited spot rarely reaching 4 mm. diameter, but sometimes so numerous that the leaf is quickly destroyed. Well known. May occur late on first crop or at any time in the summer and autumn.

2. Leaf-blotch caused by Pyrenopeziza medicaginis. Widespread. Elongate blotches tending to be restricted by veins, becoming yellow, finally brown or even blackened at the center. Develops slowly, and thus becomes most severe on plants which stand long between cuttings.

3. Pseudoplea leaf-spot caused by Pseudoplea briosiana. Central and Southern States. The fungus infects only very young leaves, preferably those produced in wet weather, and therefore the disease is severe, chiefly in young growth started during warm rainy weather. Pale brown spots, more abundant at margins. Young shoots may be stunted.

4. Stemphylium (or Macrosporium) leaf-spots caused by Stemphylium botryosum.
Chiefly Eastern States. Brown spots, varying greatly in size, sometimes abundant and destructive. The conidia of the causal fungus are spiny and this character serves to differentiate it from a closely related fungus with smooth-walled spores, which attacks red clover.

5. Cercospora leaf-spot caused by Cercospora medicaginis. Chiefly Central and Southern States. Spots usually not numerous, often olivaceous, but sometimes brown, and easily confused with the preceding leaf-spots.

Note: The recorder will undoubtedly have extreme difficulty in differentiating these leaf-spots except in the case of the common Pseudopeziza leaf-spot and the distinctive leaf-blotch. If leaf-spots appear in epidemic form, he is advised to consult a local plant pathologist.

6. Rust caused by Uromyces medicaginis.
Alfalfa rust is usually common on the third cutting in the Eastern States and has been reported also from Kansas, Oklahoma, Texas, California, and other Western States. The disease is characterized by dark brown masses of fungus spores which rupture the epidermis of the leaves and stems and form typical, powdery, rust pustules.

IV. Insect injuries.

A. Leafhopper yellowing caused by the potato leafhopper (Empoasca fabae) Plants are dwarfed and the shoots are yellowed at the tips. The yellowing is often accompanied by a noticeable reddening, bronzing, or purpling. Tipburn of the leaflets is common and there is usually an abnormal development of lateral branches on the affected shoots. The chief signs of the injury are the abundance of active, green adult leafhoppers in the nursery and the presence of small, yellowish leafhopper nymphs on the plants. Leafhopper yellowing commonly affects the second cutting and in some nurseries the third cuttings may yellow also.